Flexible Optoelectronic Technology Applied in Organic Light Emitting Diode (OLED)

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ABSTRACT

The development of Flexible Optoelectronic applied in Organic Light Emitting Diode (OLED), using an flexible optically transparent substrate material and organic semiconductor materials, has been widely utilized by the electronic industry when producing new technological products. The OLED are the base Poly (3,4-ethylenedioxythiophene)-Poly(Styrenesulfonate), PEDOT:PSS, and Poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene], MEH-PPV, were deposited in Indium Tin Oxide, ITO, and characterized by UV-Visible Spectroscopy (UV-Vis), Optical Parameters (OP) and Scanning Electron Microscopy (SEM). The result obtained by UV-Vis has demonstrated that the PET/ITO/PEDOT:PSS/MEH-PPV layer does not have displacement of absorption for wavelengths greaters after spin-coating. Thus, the spectral irradiance of the OLED informed the luminance of 180 Cd/m^2, and this result, compared with the standard Light Emitting Diode (LED), has indicated that the OLED has higher irradiance. After 2000 hours of electrical OLED tests, the appearance of nanoparticles visible for images by SEM, to the migration process of organic semiconductor materials, was present, then. Still, similar to the phenomenon of electromigration observed in connections and interconnections of microelectronic devices, the results have revealed a new mechanism of migration, which raises the passage of electric current in OLED.

Keywords: OLED; PEDOT:PSS; MHE-PPV; ITO.

1. INTRODUCTION

In 1977, a new chapter in the evolution of organic semiconductor materials began, when Hideki Shirakawa, from the University of Tsukuba (Japan), Alan Macdiarmird, from the University of Pennsylvania, and Alan J. Heeger from the University of Santa Barbara (The U.S.), demonstrated the existence of conductive properties for doped Polyacetylene (intrinsically an insulator), which assured them the Nobel Prize in Chemistry, in 2000 [1][2]. Research studies, realized to synthesize and characterize the components of this new class of materials, have been currently passing through a continuous process of technological advance in search of new conductive polymers. In addition, the greatest interest in studying organic semiconductor materials has been present in its potential applications, among which are: lightweight batteries, organic sensors, gas sensors, electrochromic devices, capacitors, electrochemical cells, organic solar cells, organic light emitting diodes, shielding of electromagnetic radiation, artificial muscles, passivation of integrated circuits MOSFET, pn junction, satellites weighing less than 0.2 kg, and others [3] [4].

Thin films made of organic semiconductor materials have drawn the attention of research groups, due to its enormous potential for its application in various industries as well as the impact their results can give to technological development. Moreover, the characterization and application of new techniques for the deposition of organic semiconductor materials has been the main focus of a large number of studies, being, thus, essential in reducing production costs [5]. Furthermore, OLEDs can be utilized for large and small areas of flat panel flexible self-luminous displays, in many consumer products. Organic light emitting diodes are electronic devices made by placing a thin film of an electroluminescent organic material between two conductors with different work functions. When an electrical voltage is applied, electrons and holes are injected into the electroluminescent material, and, when they are recombined, light is emitted [6][7]. This research aims to develop thin films electroluminescent organic material for OLED, by using the spin-coating technique, and characterizing the layers and devices utilizing UV-Visible Spectroscopy (UV-Vis), Optical Parameters (OP) and Scanning Electron Microscopy (SEM) techniques.

2. EXPERIMENTAL DETAILS

The Organic Light Emitting Diode, developed in this research, has been manufactured by utilizing flexible optically transparent material, covered by a layer of ITO, with 200 nm thick. The ITO has high conductivity and transmittance in the visible region of the electromagnetic spectrum, which enables their utilization, for instance, in OLED, organic gas sensors, organic transistors and electrochromic devices [8-9].

The Poly (3,4-ethylenedioxythiophene)-Poly (Styrenesulfonate), PEDOT:PSS, layer was deposited through the spin-coating technique, adding from 100 to 100 µL at 400 rpm for five seconds in each deposition. On these layers, a conjugated polymer, corresponding to the active layer, has been deposited. This layer deposited through the Poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene], MEH-PPV, spin-coating technique, was prepared with Chloroform and Toluene (10^{-6}mol/L), utilizing 100 to 100 µL at 400 rpm for five seconds in each deposition. The spin-coating system utilized in this experiment has been presented in figure 1.

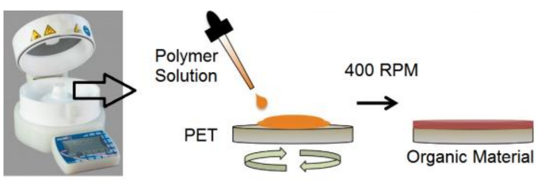

Figure 1. The Spin-coating System.

The developed Organic Light Emitting Diode device has presented a PET/ITO/PEDOT:PSS/MHE-PPV/Al configuration layered, as represented schematically in figure 2.

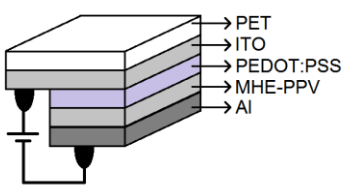

Figure 2. The Configuration of the OLED Device.

3. DISCUSSION

The analysis of a sample through the ultraviolet-visible spectroscopy has been the result in a spectrum of light, obtained by a graph of wavelength, or frequency versus the intensity of absorption (absorbance or transmittance) [7] [8]. The absorption spectrum in the spectral region of 200-1100 nm, of the OLED, has been shown in figure 3. This result has indicated that there is no increase in the absorbance with the spin-coating technique of organic materials.

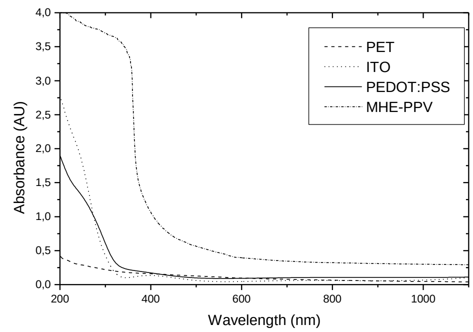

Figure 3. UV-Vis Spectroscopy of OLED.

The spectral irradiance of the OLED has been shown in figure 4. The Luminance of this OLED is of 180 Cd/m^2. This optical parameter has indicated that the OLED operates in a wavelength region of 460-670 nm. This result, compared with the standard Light Emitting Diode (LED), has indicated that the OLED has higher irradiance and luminance.

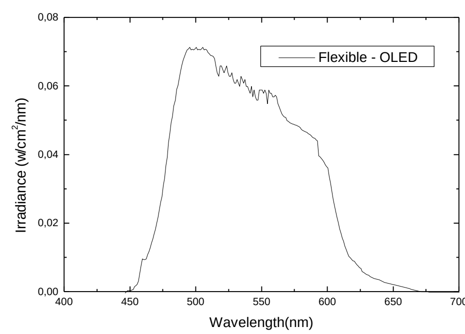

Figure 4. Spectral Irradiance of OLED.

The microscopic analysis performed in OLED by Scanning Electron Microscopy, has allowed us to observe the induction on the surface of the samples before and after the application of voltage. Figure 5 has shown the micrograph of OLED before applying voltage. It may be observed that the surface of the sample has some homogeneous aspect, plane and without changes.

Figure 6 has shown the micrograph of OLED after application of 5.0 volts during 1000 hours. In this micrograph, it may be observed the surface of the sample in some irregular aspect, with holes and cracks. In addition, the formation of nanoparticles due to the migration of the organic semiconductor material can be observed. Furthermore, an increase of time, when utilizing the device, and an increase in the application of voltage, may be observed as well as the existence of an increase in the formation of nanoparticles. Therefore, these nanoparticles can contribute to reducing the lifetime of the OLED, since the accumulation of organic semiconductor material may cause short circuit in the device.

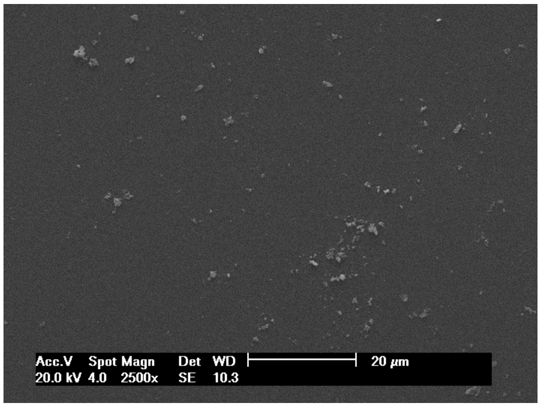

Figure 5. SEM of OLED before applying voltage.

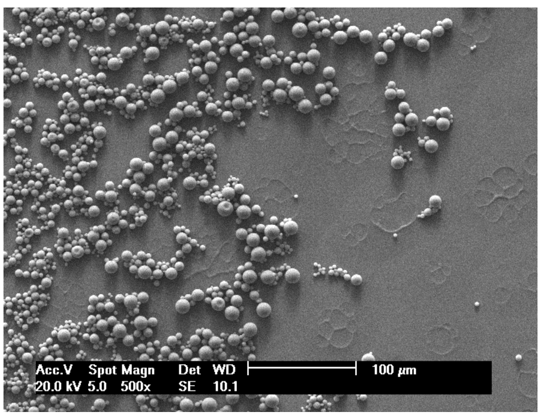

Figure 6. SEM of OLED after applyng voltage.

4. CONCLUSIONS

The results presented in this research are that PEDOT:PSS/MHE-PPV can be utilized as an active layer of OLED. These organic semiconductor materials can be deposited spin-coating. The absorption spectrum in the spectral region of 200-1100 nm of the OLED, has indicated that there is no increase in absorbance with the utilization of these deposition techniques. The spectral irradiance of the OLED informed the luminance of 180 Cd/m^2. This result, compared with the standard Light Emitting Diode, (LED) has indicated that the OLED has higher irradiance and luminance. The new phenomenon of migration, observed in OLED, demonstrated similarities with that observed in microelectronic devices. In OLED devices this new migration mechanism that rises with the passage of electric current can influence the lifetime reduction of devices.

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